Intelligent Tutoring System in GE3D Virtual Campus

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***Abstract*-Nowadays, improving the quality of learning by facilitating access to resources from home or workplace is the great challenge of e-learning. LMSs (Learning Management Systems) are quite ubiquitous and choosing one is difficult. These LMSs often share the same features: lacking in ergonomics or being only used as documents repositories [1]. As a consequence, learners and teachers use those tools, what's worse, students might give up. Following a social-constructivist approach to learning and the expectations of the students and teachers, we realized a 3D virtual campus (GE3D) [2]. This virtual world frames efficient new media for collaborative education. It allows lectures, workshops and exercises, with synchronous connections for users. The instant reactivity of this 3D site makes immediate appropriation easier for students and teachers, and thus, builds a user community with a great level of participation. The connected users can help one another by sharing their knowledge. Considering cost or hazard while using real equipments, distance learners can carry out tasks in a safe and cost-effective way in virtual environments. We describe the architecture of the ITS (Intelligent Tutoring System), which supplies additional help to learners and teachers. The client-server architecture of GE3D is standard, inexpensive, and adapted to the needs and equipment of developing countries. This article describes the use of GE3D in a common scenario for a course on PLC's (Programmable Logical Controllers). Then, considering students' feedbacks, we suggest to integrate learning taxonomies in the ITS engine.**

Keywords-Component; Virtual World for Academic; Intelligent Tutoring System; Multi-agent System; Enhanced Learning; Synchronous Technologies; Learning Style; GE3D

I. INTRODUCTION

The European Commission gives us the following definition: "E-Learning: the use of new multimedia technologies and the Internet to improve the quality of learning by facilitating access to resources and services as well as remote exchanges and collaboration." Thus, Information Technologies are used in LMSs (Learning Management Systems) to give distance learners an access to knowledge.

During the past fifty years, progress was made in approaches to learning [3], particularly the passage from the behaviorist to cognitive approach has been extended to constructivism. This evolution concerns the goals of learning, the content, learners' and teachers' role and knowledge acquisition.

Behaviorism emerged in the 1930s. Students will learn when they give a correct answer to a stimulus from the environment, one noticeable characteristic here being the emphasis on repetition.

Cognitivism emerged in reaction to behaviorism, under the influence of the growing interest in the information process. It is based on the principles that learning is an active and constructive process. Learning is the establishment of links between new information and prior knowledge, and finally, it concerns declarative, procedural, and conditional knowledge [4].

Constructivism is based on the principle that learning is an active process of knowledge construction, rather than a process of acquisition of knowledge [5]. The concept of knowledge construction is built by the individual, thanks to his/her interactions with his/her environment according to his/her experience.

Socio-constructivism focuses on the relational dimension of learning [6]. In fact, the student develops his/her understandings by comparing his/her own perceptions with those of peers and teachers.

These learning theories influence the conception of LMS. The technical headways in network management and the increasing flows of data, more and more enrich the educational contents with video or sound. They also allow the use of online simulators. Indeed, in engineering syllabi, the cost and dangerousness of equipments prompt us to use simulators with students. These simulators have to look like real environments in order to catch learners' interest. Thus students must be able to reinvest the knowledge gained with simulators in real life.

The targeting of a simulator closed to reality, forces us to follow the evolution of the technologies integrated into video games. For example, today it is possible to include gravity effects into the movement of an object with great realism [7]. These new tools can be included in simulators.

However, there is another difficulty in distance learning on how to prevent learners from dropping-out. According to Carr [8], the desertion rate is higher by 10-20% when compared to face-to-face classroom. To avoid this problem, an appropriate choice of LMS must be made, corresponding to the learner's profile. Besides we also provide personal monitoring for the student.

II. PROBLEM

Today LMSs are used all over the world, for in-service training or by universities in initial training. Indeed, on the Internet, we find a large number of companies worldwide proposing all sorts of trainings in e-learning. Universities also use LMSs and mainly Moodle [9]. These platforms are generally used as a library or as a repository for documents. This practice corresponds to a public used to work autonomously, but, which might entail dropping out for a student discovering universities. The platform has to be a zone of exchange and communication supporting the acquisition of knowledge by links established between the end users belonging to the same community of interest.

The ergonomics of the Moodle platform is also a brake on its use either on the teaching side or student side. Besides its use like a zone of deposit, this LMS offers numerous tools (on-

line MCQ, etc.) that few people use because of their lack of ergonomics.

Having tested our LMS Moodle and having asked our students their expectations about this kind of tool, we have built the GE3D platform.

III. A SOLUTION

A. Analyzing Requirements

Our students are young (19-20 years old), in their first academic year, in the Engineering studies. When we ask them what they expect from an LMS, they answer they want to:

- Be connected all together simultaneously;
- Have access to their marks, to their timetables;
- Have complements to their traditional courses;
- Have additional exercises;
- Have one hotline with teachers;
- Communicate with each other;
- Have an easy-to-use site.

The second group of potential users, teachers, also gives us their expectations concerning an LMS. They wish:

- A useful platform for any subject (mathematics, physics, languages, etc.);
- A simple and ergonomic platform;
- A platform accepting various supports of courses (document, video, etc.);
- A platform with sound (particularly in language studies);
- A platform with which one can re-use already-made documents.

B. The GE3D Platform

When we had a look at the students' expectations and the professors' needs, a common point appeared. Both groups want to find in an LMS what they have at the university every day. Respecting these viewpoints, we have built a virtual site in 3D similar to university premises. GE3D contains six rooms (Fig. 1):

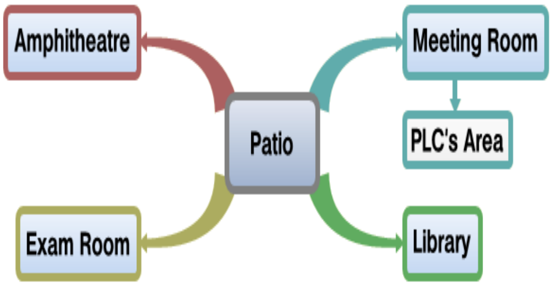

Figure 1 The site plan of GE3D

- The Patio where connected users "land" arriving at the campus;
- The Amphitheatre, a room for lectures;
- The Examination room for e-assessments;
- The Library for newspapers, e-books and other media;
- The Meeting Room for collaborative jobs in a small group;
- The PLC's Room for practical workshops.

In Fig. 2, we can see the patio: the room for entrance. Inside, students consult their schedules, their assessments and other information. At the bottom of the image, we can see a public chat zone. We also notice, at the bottom of the screen, the pager button used for private chat. The connected user is represented in 3D by a photograph as an avatar.

Figure 2 The entrance of the GE3D web site

In Fig. 3, we can see the amphitheatre which is generic. It allows making any kind of lecture (mathematics, physics …) by showing various documents on the screen. Only the professor has access to the microphone here. Students ask questions via the public chat, and then the professor answers with the microphone to all students.

Figure 3 The amphitheatre for lecturing in the GE3D web site

In Fig. 4, the examination room is presented. Here the students can take an exam which is an e-assessment with multiple-choice questions. No means of communication are available for them in this room. Obviously, in the structure of the assessment, we can introduce video, drawings, or formulas. Then, the multiple-choice questions can be adapted for all the syllabi. As soon as they finish their examination, they can see their marks.

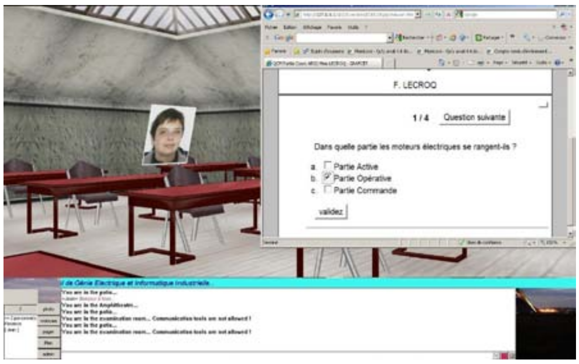

Figure 4 The examination room at the GE3D web site

In the next room (Fig. 5), any student can use a whiteboard. This allows them to work together on one exercise. Simultaneously, all the connected people can interact with the whiteboard. This room is also a generic room where any discipline of teaching can be offered.

Figure 5 The exercise room on the GE3D web site

The next room (Fig. 6) is specific for teaching on PLC's (Programmable Logic Controllers). The students can see the movement of the rod of a cylinder by the activation of a SFC (Sequential Function Chart) which is associated with it. According to the evolution of the SFC, the rod goes in or out of the cylinder. This animation is synchronized on all connected computers. Students have access to the other processes which they have to study before going in the real room of PLC's at the university where they test their own solution.

Figure 6 The Programmable Logic Controllers (PLC's) room on the GE3D web site

To support students and teachers in their own activities, we suggest plugging in GE3D an artificial intelligence component.

C. The Intelligent Tutoring System

Broadly defined, an ITS (Intelligent Tutoring System) is an educational software containing an artificial intelligence component. The software tracks students' work, tailoring feedback and hints along the way. By collecting information on a particular student's performance, the software can make inferences about strengths and weaknesses, and can suggest additional work [10].

The previous definition does not give any clue about how to design the dedicated artificial intelligence component. Let's start by analyzing the key points of the issue to tackle.

In computer science, there is a relationship of interdependence between the characteristics of a problem to solve, the representation of data and the algorithm used to solve the problem. " Dynamic problems in computational complexity are problems stated in terms of the changing input data: given a class of input objects, find efficient algorithms and data structures to answer a certain query about a set of input objects each time the input data are modified" [11].

Input data come from observed traces let by users when interacting with the computer environment and store in an attribute-value relation form. As an example, the Seine is a 777 kilometer-long river rising in the Langres plateau. The 9th of January 2012, in Paris, the recorded flow was 970 cubic meters per second and the river was 3.3 meter high:

<factA>

<type>river</type>

<name>Seine</name>

<date>9 january 2012</date>

<long>777</long>

<rise>Langres plateau</rise>

</factA>

<factB>

<type>river</type>

<name>Seine</name>

<date>9 january 2012</date>

<flow>970</flow>

<height>3.3</height>

</factB>

The following scheme (Fig. 7) displays relations between observed facts and dynamic problems.

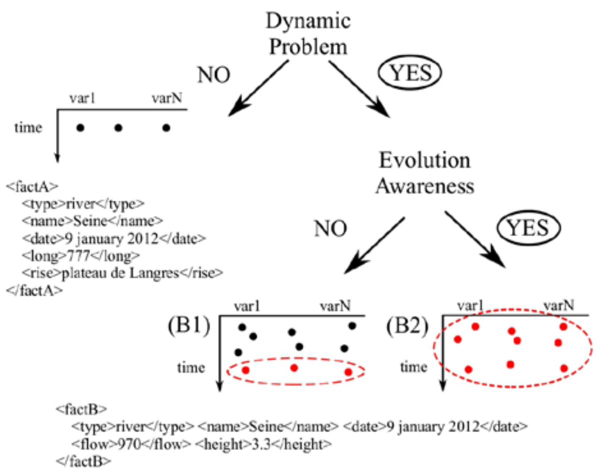

Figure 7 Typology of dynamic problem

Unless dealing with a long geologic time scale, fact A is useless for dynamic problem because it will never change. The only knowledge of last values can be adequate (B1) for some class of problems: for example, knowing if there is enough water to cruise a boat under a given bridge. ITS needs to take into account evolutions of values (B2) to track students' work and suggest additional work.

Fig. 8 shows the architecture of the ITS. In line with Wooldrigde [12], considering the dynamic characteristics of the problem, we chose a Multi-Agent System (MAS) architecture of the artificial intelligence component of the system. For the representation layer, each fact is associated with a given agent in which internal data structures are updated according to the dynamic evolution of the fact. Inside the MAS,

agents communicate and change according to their semantic proximity with the updated fact.

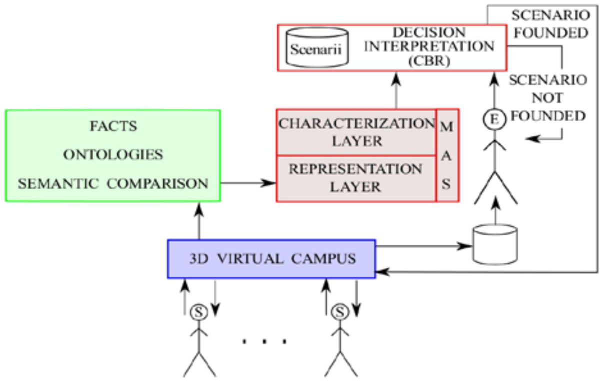

Figure 8 The ITS architecture

Semantic proximity is computed by a function based on an ontology of the domain. The characterization layer weighs a profile consistent with the situation and its evolutions as seen by representation layer. The outputs of characterization layer enriched by expert (E) analysis enrich case-based reasoning (CBR).

Virtual campus is the human-computer interface for learners. The multi-agent system permanently receives data from learners and uses them to represent the actions of learners [13]. Those representations are compared to previous situations stored in the base of scenarios. There are two options:

1) The ITS finds one or more scenarios which are similar to the current situation. In that case, a personalized answer is provided to the given learner: suggesting a new series of exercises, proposing complementary reading, taking evaluations again, etc. A special case is to call a human tutor in order to prevent the learner dropping out.

2) The ITS does not find a scenario close to the current situation and then asks the expert for possibly creating a new scenario.

D. Used Technologies

This virtual campus is realized with the SCOL technology [14], which gives us the following specifications: Web3D technology, open-source for our own developments and platform independent with a client-server architecture.

The choice of a simple photo as the user's avatar preserves the fluidity of moves in the 3D world and allows a large number of synchronous connections. The synchronous 3D with a representation close to the reality brings strong capacity of integration and appropriation of the site by the users.

Now, as an example, we will explain how to use the 3D site for teaching in automation.

E. Teaching PLC's with GE3D

The chosen scenario for teaching the PLC's is the following:

1) An appointment is given to all students in the amphitheatre (Fig. 9);

2) Before lecture starts, students download gap-fill lecture notes they can complete;

3) During the lecture, the teacher uses the screen to show slides or videos. He also uses the whiteboard, for writing notes or drawing diagrams, and a microphone for the audio part. At the same time, students fill the gaps in the lecture notes. If needed, they ask questions using the public chat;

4) After the lecture, in the virtual room of the examination, students take an exam which is an e-assessment, with multiple-choice questions. In case of success, they can reach the meeting room. Otherwise, they take their tests again;

5) In the meeting room, the professor gives practical exercises and students propose their solutions on the whiteboard (Fig. 10);

Figure 9 The amphitheatre in GE3D with students

Figure 10 The students in the meeting room

6) When all the exercises are completed, the group moves to the industrial room (Fig. 6). There, the professor shows how the equipments work, and he stays in the virtual room to answer students' questions;

7) When students have finished the basic exercises and have activated the virtual operative parts, they can then download the specifications of the industrial processes presented in the various videos available in the room of the PLC's;

8) Having prepared the programs of the PLC's piloting these complex industrial processes, students find the teacher in the room of the real PLC's to validate their solutions. They can also send their work by email to be corrected by the professor.

IV. STUDENTS' FEEDBACK & LEARNING STYLES

This experiment was realized by the students in the first year of the engineering studies from the Institute of Technology of Le Havre University (France). Fourteen students were simultaneously connected to the GE3D platform. The four parts courses were: an e-lecture followed by an e-assessment, then a presentation of the virtual Programmable Logic Controllers room was done. During the e-lecture in the amphitheatre, the professor and the students had access to the microphone, contrary to the scenario established in the part III B. In fact, the students were so serious during the course, that it was not a problem to give them the access to the microphone.

At the end of the e-assessment, they have access to their marks as they wanted. In the PLC's room, they have tested the movement and the evolution of the cylinder presented there. The fourth element of the course was the visualization of a movie describing the processes to realize on the real PLCs. The course was one hour and a half long. Immediately after the session, the students were free to notify the strengths and the weaknesses of the system. According to the size of the group of students, we will just present their most relevant opinions and remarks.

That is why in the future we will do more experiments with students to have quantitative results.

After analyzing the students' responses, the positive aspects were:

- The opportunity to be connected all together simultaneously on the same web site;
- The innovative and original interface;
- An online access to timetables, to results of e-assessment;
- The integrated videos available in the lecture;
- The direct web 2. O link offered by the 3D platform;
- The existing communication between peers like audio or chat;
- A higher motivation to attend lecture and participate the lecture;
- The opportunity to manipulate a virtual operating system in a real time 3D environment.

The suggested improvements concern the way to move in the stairs and to reach a seat in the amphitheatre and a reduced size for the avatars.

Thanks to simplicity of use, interactivity and attractiveness of the GE3D platform, the learners were more involved in the learning process and were looking forward to having other virtual sessions.

Using feedback from students help us to notice that combining both Bloom's taxonomy and Felder and Silverman index of learning styles could improve the ITS. Indeed adding dedicated terminologies for analyzing the students' styles and learning strategies will be valuable for agents of representation layer.

We assume that agents in the MAS must describe aspects of students' profiles. Some aspects would be better represented by Bloom's taxonomy and other aspects would be better characterized by Felder and Silverman index of learning styles [15]. The latter seems to be adequate for dealing with personal preferences in homogeneous samples of students having the same level of education or common cultural heritage. Some students seem to be more comfortable in teamwork than others who do prefer personal work. Some students inclined towards listening, and other students feel disposed to synthesize more easily.

The concept of learning styles is more complex than it seems. We cannot reduce learner's behavior to a specific and unique learning style. Students have different preferences, cognitive styles, personality types, aptitudes, and attitudes towards learning (Tab. 1).

TABLE I. INDEX LEARNING STYLES BY FELDER-SILVERMANN

ACTIVE Tries things, working in groups	**REFLECTIVE** Works alone or familiar partner
SENSING Concrete thinks, practical, facts and procedures	**INTUITIVE** Abstract, innovative, theories and meanings
VISUAL Pictures, diagrams, flow charts	**VERBAL** Written and spoken explanations
SEQUENTIAL Linear thinking, small steps	**GLOBAL** Holistic thinking, large leaps

On complement of learning styles, Bloom's taxonomy (Fig.11) offers an extra view of the current step a given student reaches inside the whole process of learning. Consequently, by tracking the level of a student in the taxonomy, the ITS could avoid suggesting applicative problems to solve to a student, who did not get over the comprehension level. This taxonomy could help the ITS to adapt the answer to match personal evolutions in the teaching process.

Identifying and using student profiles could decrease the drop-out rates.

This taxonomy of learning behaviors can be thought of as "the goals of the learning process." That is, after a learning episode, the learner should have acquired new skills, knowledge, and/or attitudes (Fig. 11).

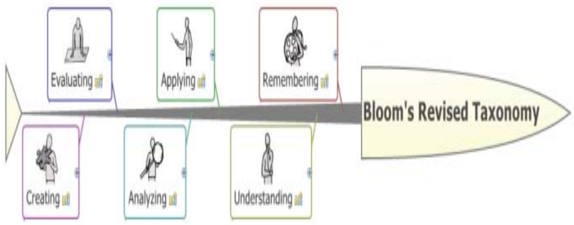

Figure 11 The Bloom's Revised Taxonomy

From Bloom [16] and Pohl [17] (Fig. 11) remembering is recall previous learned information. Understanding means comprehending the meaning, translation, interpolation, and interpretation of instructions and problems. Applying is using a concept in a new situation or unprompted use of an abstraction or applying what was learned in the classroom into novel situations in the workplace. Analyzing is the ability of separating material or concepts into component parts so that its organizational structure may be understood and distinguishing between facts and inferences. Evaluating is making judgments about the value of ideas or materials. And creating is building a structure or pattern from diverse elements and putting parts together to form a whole, with emphasis on creating a new meaning or structure.

The ITS needs to hold both a specific profile of preferences of a given learner and an estimation of the individual progression in a course. We can note that the border between these two views (on the one hand, learning style, on the other hand, pedagogical evolution) is neither clear nor easy to make explicit, because the two paradigms have an impact on each other. It is up to our ITS to meet the challenge of mixing both views to offer an accurate reply to learners.

Works are in progress to describe and consider the two points of view by creating a mixed ontology. The ITS will not detect in the same way a student reaching application level (according to Bloom's revisited taxonomy) if this student prefers verbal than visual style (according to Felder-Silverman). Mixing views will ensure a better description inside the ITS of the learner's evolutions in the environment and the coherent behavior of the MAS. The representation layer of dynamical situations is a critical step of the whole system as other layers rely on accuracy which the MAS represents situations. It would be an illusion to believe that the system could detect a scenario using observable facts if the representation layer does not precisely take care of those facts. Ontology needs to describe, represent, and characterize very precisely observed and deduced facts perceived by the system about evolution and learning styles in order to assist representation layer by computing semantic proximity.

V. CONCLUSION

In this article, we have described our virtual campus GE3D enhanced by the Intelligent Tutoring System. The goal of the ITS is to help the student in the learning process. We have presented an automation learning sequence for students in engineering.

The choice of the teaching sequence described in this article (lecture, tests and practical exercises) is not fixed. Indeed, this architecture allows developing project-based learning scenario for a student working alone or in a group. The problem-learning approach is also possible with a teacher playing the role of adviser and facilitator. Whatever the learning strategy retained, the ITS will take learner's learning style and personal difficulties into account. The human tutor is thus discharged of the repetitive tasks assumed by the ITS.

At the end of the teaching sessions carried out with test-groups of students, we conclude that this environment of training rightly corresponds to the students' expectations. Thanks to the same intuitive interfaces used in video games, the students appropriate this kind of environment very quickly. GE3D is also fit to teach sciences and technologies as all the fields where vision is of prime necessity in developing the interactivity between man and any experimental system.

Unlike with common LMS, learners are not left alone, facing the screen of their computer. They can now take advantage of the permanent support given by the teacher, the ITS or other students. That way, the risk of deserting the course is strongly reduced.

Considering cost-effectiveness and safety, the students can handle virtual equipments without potential accidents when using real operative parts, which are extremely costly for a school or an engineering department. And should a mistake be made, human or material damages remain virtual.

The sight of the passion expressed by the students during the use of GE3D has prompted us to increase the server capacity and the course modules available.

"I never teach my pupils; I only attempt to provide the conditions in which they can learn".

(Albert Einstein, 1879-1955)

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